5   A HARDWARE CIRCUIT AND METHOD FOR AUTOMATICALLY
CONFIGURING ON-THE-FLY A SUB-UNIT IN A SCSI MESSAGE

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10   BACKGROUND OF THE INVENTION

Field of the Invention
        The present invention relates generally to SCSI
expander devices, and more particularly to using a SCSI
15   expander with a variety of SCSI target and SCSI
initiator devices having different signal conditioning
requirements.

Description of Related Art
20   In a system that utilizes the Packetized SCSI
Protocol, there are two methods used for signal
conditioning. A first signal conditioning method,
called write precompensation (WPC), conditions the
driving signal. A second signal conditioning method,
25   called adjustable active filtering (AAF), conditions
the received signal. Unfortunately, the two signal
conditioning methods are incompatible because an AAF
input signal is overdriven if WPC is used. According
to the SCSI specification, WPC signal conditioning is
30   mandatory while AAF signal conditioning is optional.
        For the Packetized SCSI Protocol, a SCSI initiator
and a SCSI target use a Parallel Protocol Request (PPR)
message in negotiating parameters for a data transfer
between the SCSI initiator and the SCSI target over a
35   SCSI bus. Execution of the Parallel Protocol Request
message is done in two passes. The SCSI initiator

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sends a PPR message to the SCSI target with required and/or requested transfer parameters. In response to this PPR message, the SCSI target returns a PPR message with its requirements and/or requests. Both the SCSI

5   initiator and the SCSI target agree on the least common denominator of parameters for the ensuing data transfers.

A precompensation enable control bit P_EN is used in the PPR message to select whether write

10   precompensation is turned on or turned off. The device that sends the PPR message asserts precompensation enable control bit P_EN if the device wants the other device to turn on write precompensation for its drivers. Conversely, the device that sends the PPR

15   message negates precompensation enable control bit P_EN if the device implements adjustable active filtering, and wants write precompensation turned off.

This technique for activating write precompensation depending on support for adjustable

20   active filtering presents problems when using a SCSI expander that does not support adjustable active filtering because the method selected does not reflect the limitations of the SCSI expander. Figs. 1A to 1D illustrate four possible SCSI initiator and SCSI target

25   configurations using write precompensation and adjustable active filtering with a SCSI expander 102 that does not support adjustable active filtering.

In Fig. 1A, neither SCSI initiator 101 nor SCSI target 103 supports adjustable active filtering. For a

30   SCSI bus phase DATA OUT, SCSI target 103 sets precompensation enable control bit P_EN in the PPR message that is passed by SCSI expander 102 to SCSI initiator 101. When SCSI initiator 101 sends data to SCSI target 103 through SCSI expander 102 that does not

35   support adjustable active filtering, the message

correctly indicates that expander 102 requires write precompensation.

For a SCSI bus phase DATA IN, SCSI initiator 101 sets precompensation enable control bit P_EN in the PPR

5 message that is passed by SCSI expander 102 to SCSI target 101. When SCSI target 103 sends data to SCSI target 103 through SCSI expander 102 that does not support adjustable active filtering, the data transfer is successful because expander 102 required write

10 precompensation. However, the system configuration of Fig. 1A is the only one that works successfully with SCSI expander 102.

In Fig. 1B, SCSI target 105 supports adjustable active filtering and SCSI initiator 104 does not

15 support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 105 negates precompensation enable control bit P_EN in the PPR message that is passed by SCSI expander 102 to SCSI initiator 101. This message erroneously indicates to SCSI

20 initiator 101 that SCSI expander 102 supports adjustable active filtering, which is incorrect.

In Fig. 1C, SCSI initiator 106 supports adjustable active filtering, and SCSI target 107 does not support adjustable active filtering. For a SCSI bus phase DATA

25 IN, SCSI initiator 105 negates precompensation enable control bit P_EN in the PPR message that is passed by SCSI expander 102 to SCSI target 107. This message also erroneously indicates to SCSI target 107 that SCSI expander 102 does not require write precompensation.

30 In Fig. 1D, SCSI initiator 108 supports adjustable active filtering and SCSI target 109 also supports adjustable active filtering. For a SCSI bus phase DATA IN, SCSI initiator 108 negates precompensation enable control bit P_EN in the PPR message that is passed by

35 SCSI expander 102 to SCSI target 109. This message erroneously indicates to SCSI target 109 that SCSI

expander 102 does not require write precompensation.
For a SCSI bus phase DATA out, SCSI target 109 negates
precompensation enable control bit P_EN in the PPR
message that is passed by SCSI expander 102 to SCSI
5   initiator 108. This message erroneously indicates to
SCSI initiator 108 that SCSI expander 102 does not
require write precompensation.

Since the state of the precompensation enable
control bit in the PPR message considers only the
10   initiator and target, a SCSI expander is limited to
working with initiator and targets that have the same
signal conditioning as the SCSI expander.
Consequently, a SCSI expander with a given signal
conditioning is useful only in limited system
15   configurations.

SUMMARY OF THE INVENTION

According to one embodiment of the present
invention, a device includes a first I/O bus-interface
20   circuit, and an on-the-fly message manipulation circuit
connected to the first I/O bus-interface circuit. The
on-the-fly message manipulation circuit sets on-the-fly
a pre-selected sub-unit of a pre-selected message-unit
of a message to a pre-selected state as the pre-
25   selected message-unit is passed through the device.

The on-the-fly manipulation circuit also includes
a message detector module having an input coupled to
the first I/O bus-interface circuit, and a message-
detected line. In response to information indicative
30   of the message on the input, the message detector
module generates an active signal on the message-
detected line.

The on-the-fly message manipulation circuit
further includes a message-unit detector module having
35   a message-unit detected line. The message-unit
detector module generates an active signal on the

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message-unit detected line upon detecting the pre-selected message-unit of the message.

In addition, the on-the-fly message manipulation circuit further includes a message sub-unit state

5   selection module coupled to the message-detected line and to the message-unit detected line. The message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the message to the pre-selected state after receiving the

10 active signal on the message-detected line, and the active signal on the message-unit detected line.

In yet another embodiment, a SCSI expander includes a first SCSI bus-interface circuit, a second SCSI bus-interface circuit, and a SCSI message

15 manipulation circuit connected to the first and second SCSI bus-interface circuits. The SCSI message manipulation circuit is one embodiment of an on-the-fly message manipulation circuit. The SCSI message manipulation circuit sets a pre-selected sub-unit of a

20 pre-selected message-unit of a SCSI message to a pre-selected state as the pre-selected message-unit is passed through the SCSI expander, i.e., on-the-fly. Hence, this SCSI expander can be used in a system that includes SCSI devices using any desired type of signal

25 conditioning for example.

The SCSI manipulation circuit also includes a message detector module. The message detector module includes an input coupled to the first and second SCSI bus-interface circuits, and a message-detected line.

30 In response to information indicative of the SCSI message on the input, the message detector module generates an active signal on the message-detected line.

The SCSI message manipulation circuit further

35 includes a message-unit detector module having a message-unit detected line. The message-unit detector

module generates an active signal on the message-unit detected line upon detecting the pre-selected message-unit of the SCSI message.

The SCSI message manipulation circuit includes a
5 message sub-unit state selection module coupled to the message-detected line and to the message-unit detected line. In one embodiment, the message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the SCSI message to the
10 pre-selected state after the signal on the message-detected line goes active, and the active signal on the message-unit detected line is received.

In another embodiment, the message sub-unit state selection module further includes an enable line. The
15 message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the SCSI message to the pre-selected state only when an active signal is on the enable line.

In one embodiment, the SCSI message is a SCSI
20 Parallel Protocol Request Message (PPR message). One embodiment of the SCSI expander of this invention does not support adjustable active filtering signal conditioning. In another embodiment, the SCSI expander of this invention supports adjustable active filtering
25 signal conditioning. In the embodiment for the SCSI PPR message, the pre-selected message-unit has a size of one byte and the pre-selected sub-unit is a precompensation enable control bit in that byte.

Herein, adjustable active filtering and adjustable
30 active filtering signal conditioning are the same thing. Similarly, herein, write precompensation and write precompensation signal conditioning are the same thing.

In yet another embodiment of the present
35 invention, a device includes a message manipulation circuit that in turn includes a message-detected line,

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a message-unit detected line, and a message sub-unit
state selection module connected to the message-
detected line and to the message-unit detected line.
The message sub-unit state selection module sets a pre-
5   selected sub-unit of a pre-selected message-unit of a
message to a pre-selected state after receiving an
active signal on the message-detected line, and an
active signal on the message-unit detected line.

In still another embodiment of the present
10   invention, a SCSI expander includes a SCSI message
manipulation circuit that in turn includes (a) a
message detector module including a message decoder
coupled to receive information indicative of a SCSI
message from a SCSI bus, and a message-detected line
15   connected to the message decoder where the message
decoder generates an active signal on the message-
detected line upon decoding the information indicative
of the SCSI message; (b) a message-unit detector module
including a counter wherein the counter counts message-
20   units in the SCSI message, a message-unit selection
register, a comparator connected to the counter and to
the message-unit selection register, and a message-unit
detected line connected to the comparator, where the
comparator generates an active signal on the message-
25   unit detected line upon receiving a value from the
counter that has a pre-selected relationship to a value
stored in the message-unit selection register to
indicate that a pre-selected message unit has been
detected, and (c) a message sub-unit state selection
30   module connected to the message-detected line and to
the message-unit detected line where the message sub-
unit state selection module sets a pre-selected sub-
unit of the pre-selected message-unit of the SCSI
message to a pre-selected state upon receiving the
35   active signal on the message-detected line, and the
active signal on the message-unit detected line, as the

pre-selected message-unit passes through the SCSI
expander.

The message sub-unit state selection module has an
output bus having a plurality of output lines and a
5   first plurality of logic gates. An output terminal of
each logic gate of the first plurality of logic gates
is selectively coupled to and selectively decoupled
from a different output line of the output bus. An
input bus has a plurality of input lines where each
10   line in the plurality of input lines is connected to a
first input terminal of a different logic gate in the
first plurality of logic gates.

The message sub-unit state selection module also
has a second plurality of logic gates. An output
15   terminal of each logic gate of the second plurality of
logic gates is connected to a second input terminal of
the different logic gate in the first plurality of
logic gates. The message-detected line is connected to
a first input terminal of each logic gate of the second
20   plurality of logic gates. The message-unit detected
line is connected to a second input terminal of each
logic gate of the second plurality of logic gates.

The message sub-unit state selection module
further includes an encoder having an enable sub-unit
25   output bus-including a plurality of lines. Each line
in the enable sub-unit output bus is connected to a
third input terminal of a different logic gate in the
second plurality of logic gates. A sub-unit selection
register is connected to the encoder.

30   A method for configuring a pre-selected sub-unit
of a message on-the-fly includes:

detecting the message using a hardware
circuit in a device;

detecting a pre-selected message-unit of the
35   message using the hardware circuit; and

configuring the pre-selected sub-unit of the
pre-selected message-unit of the message to a pre-
selected state using the hardware circuit as the
pre-selected message-unit is passed through the
5   device.

While a pre-selected sub-unit in a pre-selected
unit is manipulated on-the-fly, in one embodiment, in
another embodiment, multiple pre-selected sub-units in
the pre-selected unit are manipulated on-the-fly. In
10   still another embodiment, pre-selected sub-units in
multiple pre-selected units are manipulated on-the-fly.
In still another embodiment, any or all of these
actions are performed on-the-fly on multiple messages.
Hence, the use of a specific message, a specific pre-
15   selected unit in that message, and a pre-selected sub-
unit in that unit is illustrative only and is not
intended to limit the invention to this specific
embodiment.

20   BRIEF DESCRIPTION OF THE DRAWINGS
        Fig. 1A is an illustration of a prior art system
that includes a SCSI initiator that does not support
AAF signal conditioning, a SCSI expander that does not
support AAF signal conditioning, and a SCSI target that
25   does not support AAF signal conditioning.
        Fig. 1B is an illustration of a prior art system
that includes a SCSI initiator that does not support
AAF signal conditioning, a SCSI expander that does not
support AAF signal conditioning, and a SCSI target that
30   supports AAF signal conditioning that results in an
incorrect configuration in the SCSI phase DATA OUT.
        Fig. 1C is an illustration of a prior art system
that includes a SCSI initiator that supports AAF signal
conditioning, a SCSI expander that does not support AAF
35   signal conditioning, and a SCSI target that does not

support AAF signal conditioning that results in an incorrect configuration in the SCSI phase DATA IN.

Fig. 1D is an illustration of a prior art system that includes a SCSI initiator that supports AAF signal
5   conditioning, a SCSI expander that does not support AAF signal conditioning, and a SCSI target that supports AAF signal conditioning that results in an incorrect configuration in the SCSI phases DATA OUT and DATA IN.

Fig. 2A is an illustration of a system that
10   includes one embodiment of a SCSI expander of the present invention with a message manipulation circuit.

Fig. 2B is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander
15   of the present invention that does not support AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2C is an illustration of a system that includes a SCSI initiator that does not support AAF
20   signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that supports AAF signal conditioning.

Fig. 2D is an illustration of a system that
25   includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

30   Fig. 2E is an illustration of a system that includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that supports AAF
35   signal conditioning.

Fig. 2F is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal

5   conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2G is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander

10   of the present invention that supports AAF signal conditioning, and a SCSI target that supports AAF signal.

Fig. 2H is an illustration of a system that includes a SCSI initiator that supports AAF signal

15   conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2I is an illustration of a system that

20   includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal conditioning, and a SCSI target that supports AAF signal conditioning.

25   Fig. 3 is a detailed diagram of one embodiment of the SCSI message manipulation circuit of the present invention.

Fig. 4A is one embodiment of clocking the counter of Fig. 3.

30   Fig. 4B is another embodiment of clocking the counter of Fig. 3.

Fig. 4C is a timing diagram for assisting in the understanding of the clocking of the counter of Fig. 3.

In the drawings and the following detailed

35   description, elements with the same reference numeral are the same or similar elements. Also, the first

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digit of a reference numeral for an element is the
number of the figure in which that element first
appears.

5   DETAILED DESCRIPTION

According to one embodiment of the present
invention, a SCSI message manipulation circuit 250 in a
SCSI expander 200A (Fig. 2A) detects a specified SCSI
message from either a SCSI initiator 201, or a SCSI
10   target 202. After detecting the specified SCSI
message, SCSI message manipulation circuit 250 detects
a pre-selected message-unit, e.g., a byte, within the
message. Upon detecting the pre-selected message-unit,
SCSI message manipulation circuit 250 sets a pre-
15   selected sub-unit, e.g., a bit, within the pre-selected
message-unit to a pre-selected state, which is
programmable, as the SCSI message passes through SCSI
expander 200A.

Specifically, the message content is manipulated
20   on-the-fly, which means that the message is not stored,
manipulated, and then released, as the message content
is transferred through a device. The message
manipulation circuit of this invention can be used in
any device as the message is transferred through the
25   device from an I/O bus or other communication medium.

A pre-selected sub-unit in a pre-selected unit is
manipulated on-the-fly, in one embodiment. In another
embodiment, multiple pre-selected sub-units in the pre-
selected unit are manipulated on-the-fly. In still
30   another embodiment, pre-selected sub-units in multiple
pre-selected units are manipulated on-the-fly. In
still another embodiment, any or all of these actions
are performed on-the-fly on multiple messages. Hence,
the use of a specific message, a specific pre-selected
35   unit in that message, and a pre-selected sub-unit in

that unit is illustrative only and is not intended to limit the invention to this specific embodiment.

In one embodiment, as explained more completely below, the specified SCSI message is a Parallel

5   Protocol Request (PPR) message, the pre-selected message-unit is a specific byte in the PPR message, and the pre-selected sub-unit is the precompensation enable control bit P_EN in the specific byte. However, SCSI message manipulation circuit 250, or an equivalent of

10   circuit 250 can be used for multiple SCSI messages as well as for multiple message-unit and sub-unit sizes within the messages. In general, message manipulation circuit 250 can be utilized in any configuration where it is desired to modify content of a message that is

15   being transmitted between two devices, i.e., the message content is manipulated on-the-fly.

SCSI message manipulation circuit 250 does not affect any SCSI message other than the specified SCSI message. In addition, SCSI message manipulation

20   circuit 250 does not adversely affect SCSI message throughput latency.

As explained more completely below, SCSI expander 200A can be used with any desired combination of SCSI devices with and without adjustable active

25   filtering. Consequently, when SCSI message manipulation circuit 250 is included in any SCSI expander with or without adjustable active filtering, the prior art problems associated with a SCSI expander not supporting adjustable active filtering are

30   eliminated without affecting the message handling performance of the SCSI expander. Figs. 2B to 2E are illustrations of various system configurations with a SCSI expander 200B that does not support adjustable active filtering, but that does includes SCSI message

35   manipulation circuit 250. In Figs. 2B to 2E, SCSI buses 291 and 292 are illustrated separately for SCSI

bus phases DATA IN and DATA OUT for convenience in illustrating the various states of precompensation enable bit P_EN for the various configurations, and this should not be interpreted as requiring two

5 different buses to connect the expander of this invention to a SCSI device.

Prior art SCSI expander 100 supported a system configuration having only SCSI initiators and SCSI targets that did not support adjustable active

10 filtering signal conditioning. As explained more completely below, any SCSI target or SCSI initiator independent of the type of signal conditioning supported can be used with SCSI expander 200B.

For example, in Fig. 2B, SCSI expander 200B

15 (Fig. 2B) is used in a system configuration having only SCSI initiators and SCSI targets that do not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 202B sets precompensation enable control bit P_EN in the PPR message that is passed to

20 SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus two interface 220, which turns on write precompensation, to SCSI message manipulation circuit 250. SCSI message manipulation circuit passes the PPR message without modification to

25 SCSI bus one interface circuit 210 that in turns passes the unmodified PPR message to SCSI initiator 201B. In response to the PPR message, SCSI initiator 201B turns on write precompensation.

For a SCSI bus phase DATA IN, SCSI initiator 201B

30 sets precompensation enable control bit P_EN in the PPR message that is passed to SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus one interface 210, which turns on write precompensation, to SCSI message manipulation circuit

35 250. SCSI message manipulation circuit passes the PPR message without modification to SCSI bus two interface

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circuit 220 that in turns passes the unmodified PPR message to SCSI target 202B. In response to the PPR message, SCSI target 202B turns on write precompensation.

5   Hence, the system configuration of Fig. 2B works successfully with SCSI expander 200B. In addition, as shown below, when a system includes either a SCSI initiator, a SCSI target, or both that supports adjustable active filtering signal conditioning, SCSI

10   expander 200B correctly interacts with each device.

        In particular, as illustrated in Fig. 2C, SCSI target 202C supports adjustable active filtering and SCSI initiator 201B does not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI

15   target 202C negates precompensation enable control bit P_EN in the PPR message that is sent to SCSI expander 200B over SCSI bus 292. The PPR message is routed through SCSI bus two interface 220, which turns off write precompensation in response to the PPR

20   message, and routes the PPR message to SCSI message manipulation circuit 250 that in turn routes a modified PPR message to SCSI bus one interface circuit 210.

        SCSI message manipulation circuit 250, as explained more completely below, changes the state of

25   precompensation enable control bit P_EN in the PPR message on-the-fly from negated to asserted. Otherwise, the message is passed unchanged by circuit 250 to SCSI bus one interface circuit 210. SCSI bus one interface circuit 210 passes the modified

30   PPR message over SCSI bus 291 to SCSI initiator 201B that in turn turns on write precompensation. Hence, the modified PPR message correctly indicates to SCSI initiator 201B that SCSI expander 202B requires write precompensation.

35   For a SCSI bus phase DATA IN (Fig. 2C), SCSI initiator 201B sets precompensation enable control

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bit P_EN in the PPR message that is passed to SCSI
expander 200B. In SCSI expander 200B, the PPR message
is passed through SCSI bus one interface 210, which
turns on write precompensation, to SCSI message

5   manipulation circuit 250. SCSI message manipulation
circuit passes the PPR message without modification to
SCSI bus two interface circuit 220 that in turns passes
the unmodified PPR message to SCSI target 202C. In
response to the PPR message, SCSI target 202C turns on

10   write precompensation. Hence, unlike the prior art
system of Fig. 1B, the correct signal conditioning is
used for each segment of the path between SCSI
initiator 201B that does not support adjustable active
filtering to SCSI target 202C that supports adjustable

15   active filtering.

As illustrated in Fig. 2D, SCSI initiator 201C
uses adjustable active filtering and SCSI target 202B
does not support adjustable active filtering. For a
SCSI bus phase DATA OUT, SCSI target 202B sets

20   precompensation enable control bit P_EN in the PPR
message that is passed to SCSI expander 200B. In SCSI
expander 200B, the PPR message is passed through SCSI
bus two interface 220, which turns on write
precompensation, to SCSI message manipulation circuit

25   250. SCSI message manipulation circuit passes the PPR
message without modification to SCSI bus one interface
circuit 210 that in turns passes the unmodified PPR
message to SCSI initiator 201C. In response to the PPR
message, SCSI initiator 201C turns on write

30   precompensation.

For a SCSI bus phase DATA IN (Fig. 2D), SCSI
initiator 201C negates precompensation enable control
bit P_EN in the PPR message that is sent to SCSI
expander 200B over SCSI bus 291. SCSI bus one

35   interface 210, which turns off write precompensation,
routes the PPR message to SCSI message manipulation

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circuit 250 that in turn routes a modified PPR message
to SCSI bus two interface circuit 220.

SCSI message manipulation circuit 250, as
explained more completely below, changes the state of
5   precompensation enable control bit P_EN in the PPR
message. Otherwise, the message is passed unchanged by
circuit 250. SCSI bus two interface circuit 220 passes
the modified PPR message over SCSI bus 292 to SCSI
target 202C. Hence, the PPR modified message correctly
10   indicates to SCSI target 202B that SCSI expander 202B
requires write precompensation. Hence, unlike the
prior art system of Fig. 1C, the correct signal
conditioning is used for each segment of the path
between SCSI initiator 201C that supports adjustable
15   active filtering to SCSI target 202B that does not
support adjustable active filtering.

As illustrated in Fig. 2E, both SCSI
initiator 201C and SCSI target 202C support adjustable
active filtering. For a SCSI bus phase DATA OUT, SCSI
20   target 202C negates precompensation enable control
bit P_EN in the PPR message that is sent to SCSI
expander 200B over SCSI bus 292. The PPR message is
routed through SCSI bus two interface 220, which turns
off write precompensation in response to the PPR
25   message, and routes the PPR message to SCSI message
manipulation circuit 250 that in turn routes a modified
PPR message to SCSI bus one interface circuit 210.

SCSI message manipulation circuit 250, as
explained more completely below, changes the state of
30   precompensation enable control bit P_EN in the PPR
message on-the-fly from negated to asserted.
Otherwise, the message is passed unchanged by
circuit 250 to SCSI bus one interface circuit 210.
SCSI bus one interface circuit 210 passes the modified
35   PPR message over SCSI bus 291 to SCSI initiator 201C
that in turn turns on write precompensation. Hence,

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the modified PPR message correctly indicates to SCSI
initiator 201C that SCSI expander 200B requires write
precompensation.

For a SCSI bus phase DATA IN (Fig. 2E), SCSI
5   initiator 201C negates precompensation enable control
bit P_EN in the PPR message that is sent to SCSI
expander 200B over SCSI bus 291. SCSI bus one
interface 210, which turns off write precompensation,
routes the PPR message to SCSI message manipulation
10   circuit 250 that in turn routes a modified PPR message
to SCSI bus two interface circuit 220.

SCSI message manipulation circuit 250, as
explained more completely below, changes the state of
precompensation enable control bit P_EN in the PPR
15   message. Otherwise, the message is passed unchanged by
circuit 250. SCSI bus two interface circuit 220 passes
the modified PPR message over SCSI bus 292 to SCSI
target 202C. Hence, the PPR modified message correctly
indicates to SCSI target 202C that SCSI expander 202B
20   requires write precompensation. Hence, unlike the
prior art system of Fig. 1D, the correct signal
conditioning is used for each segment of the path
between SCSI initiator 201C that does support
adjustable active filtering to SCSI target 202C that
25   also supports adjustable active filtering.

Prior art Figs. 1A to 1D illustrated the problems
encountered when a SCSI expander 102 that did not
support adjustable active filtering was used in systems
that included devices that utilized adjustable active
30   filtering signal conditioning. TABLE 1 summarizes the
problems when the prior art SCSI expander 102 is
replaced with a prior art SCSI expander that supports
adjustable active filtering (not shown).

TABLE 1.   Prior Art SCSI Expander that Supported
Adjustable Active Filtering

Initiator Signal Conditioning	Target Signal Conditioning	SCSI Bus Phase	P_EN State in Message to Expander (Prior Art)	P_EN State in Message From Expander (Prior Art)
WPC (Fig. 1A)	WPC	Data Out	Asserted	Asserted (Incorrect)
		Data In	Asserted	Asserted (Incorrect)
WPC (Fig. 1B)	AAF	Data Out	Negated	Negated
		Data In	Asserted	Asserted (Incorrect)
AAF (Fig. 1C)	WPC	Data Out	Asserted	Asserted (Incorrect)
		Data In	Negated	Negated
AAF (Fig. 1D)	AAF	Data Out	Negated	Negated
		Data In	Negated	Negated

5   Hence, as shown by TABLE 1, the prior art SCSI expander
that supported adjustable active filtering could only
be used successfully in systems where both the SCSI
initiators and the SCSI targets supported adjustable
active filtering signal conditioning.

10   In another embodiment of this invention, SCSI
expander 200B in Figs. 2B to 2E is replaced with
another SCSI expander 200F that supports adjustable
active filtering signal conditioning. With SCSI
expander 200F, the problems in TABLE 1 are eliminated,

15   as illustrated by TABLE 2. Figs. 2F to 2I are
illustrations of various system configurations in
TABLE 2 for a SCSI expander 200F that supports

adjustable active filtering and also includes SCSI
message manipulation circuit 250.

5   TABLE 2.   SCSI Expander that Supports Adjustable Active
Filtering, and includes SCSI Message Manipulation
Circuit

Initiator Signal Conditioning	Target Signal Conditioning	SCSI Bus Phase	P_EN State in Message to Expander	P_EN State in Message From Expander
WPC	WPC	Data Out	Set	Negated
(Fig. 2F)		Data In	Set	Negated
WPC	AAF	Data Out	Negated	Negated
(Fig. 2G)		Data In	Set	Negated
AAF	WPC	Data Out	Set	Negated
(Fig. 2H)		Data In	Negated	Negated
AAF	AAF	Data Out	Negated	Negated
(Fig. 2I)		Data In	Negated	Negated

Hence, a SCSI expander 200F, which supports adjustable
10   active filtering and includes SCSI message manipulation
circuit 250, changes the state of precompensation
enable control bit P_EN in the PPR message to correctly
indicate the type of signal conditioning required to
communicate successfully with SCSI expander 200F as
15   illustrated in Figs. 2F to 2I for each of the prior art
incompatible configurations of TABLE 1. Conversely,
for configurations that did not result in an
incompatible configuration, SCSI expander 220F passes
the PPR message through unmodified.
20   Returning to Fig. 2A, SCSI message manipulation
circuit 250, in this embodiment, includes a message
detector module 260 that detects when a selected
message is being passed between a SCSI initiator and a
SCSI target through SCSI expander 200A. In more

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message-unit in the message to a programmably selected
state as the pre-selected message-unit is passed
through expander 200A.   In another embodiment, the
selected sub-unit is hard-coded in module 280.   In
5   still another embodiment, enable input line 281 is not
used and when the signals on lines 261 and 271 are both
active, message sub-unit state selection module 280
sets the state of a programmably pre-selected sub-unit
of the pre-selected message-unit in the message to a
10   programmably selected state as the pre-selected
message-unit is passed through expander 200A.

When expander 200A is used for detecting a SCSI
PPR message, the pre-selected message-unit is a
specific byte in the message containing a
15   precompensation enable control bit, and the sub-unit is
the precompensation enable control bit.   The state of
the precompensation enable control bit is set based
upon the type of signal conditioning supported by
expander 200A.

20   Fig. 3 is a more detailed diagram of one
embodiment of SCSI message manipulation circuit 250 of
this invention.   This embodiment permits setting a bit
in a message byte to a selected state.   The bit in the
message byte, the message byte, and the state of the
25   bit are programmably selectable, in this embodiment,
i.e., are pre-selected.

Bus-in selector 380 passes the signals on one of
buses 211 from SCSI bus one interface circuit 210 and
bus 221 from SCSI bus two interface circuit 220 to an
30   input bus SDI[7:0] that includes a plurality of input
lines.   A signal level on a line DIRECT is used to
select which of the two buses 211 and 221 is connected
to bus SDI[7:0].   The signal level on line DIRECT is
determined by the direction of data transfer through
35   SCSI expander 200.

In one embodiment, bus-in selector 380 is a multiplexer. In another embodiment, bus-in selector 380 is included within each of bus-interface circuits 210 and 220 and so input bus SDI[7:0] is

5 connected to each of bus-interface circuits 210 and 220. The particular way that the input signals are selected and driven on input bus SDI[7:0] is not essential to this invention.

Each input line of bus SDI[7:0] is connected to a

10 first input terminal of a different OR gate in a plurality of OR gates 340_0 to 340_7, e.g., a first plurality of logic gates, and to a first input terminal of a different AND gate in a plurality of AND gated 360_0 to 360_7, e.g., a second plurality of logic

15 gates.

Each output line of an OR gate in plurality of OR gates 340_0 to 340_7 drives a different line in a bus 371 to multiplexer 370. Each output line of an AND gate in plurality of AND gates 360_0 t 360_7 drives a

20 different line in a bus 372 to multiplexer 370. The signals driven on output bus SDO[7:0] from one of buses 371 and 372 are selected by a level of a signal POLARITY on line 375.

In one embodiment, if circuit 250 is included in

25 an expander that does not support active adjustable filtering, the level of signal POLARITY is set, e.g., set active, so that multiplexer 370 connects bus 371 to output bus SDO[7:0] and disconnects bus 372 from output bus SDO[7:0]. Conversely, if circuit 250 is included

30 in an expander that supports adjustable active filtering, the level of signal POLARITY is set, e.g., set inactive, so that multiplexer 370 connects bus 372 to output bus SDO[7:0] and disconnects bus 371 from output bus SDO[7:0]. The state of the signal on line

35 375 could be programmed by an on-chip processor, loaded

from an external source such as a SCSI initiator, or a
host system, or alternatively hard-coded.

     In general, an output terminal of each OR gate in
plurality of OR gates 340_0 to 340_7 is selectively
5   coupled to and selectively decoupled from a different
output line of output bus SDO[7:0] by multiplexer 370.
Similarly, an output terminal of each AND gate in
plurality of AND gates 360_0 to 360_7 is selectively
coupled to and selectively decoupled from a different
10 output line of output bus SDO[7:0] by multiplexer 370,
in this embodiment.

     Output bus SDO[7:0] is connected to one of
buses 211 and bus 221, in this embodiment, by a bus-out
selector 390. One of buses 211 and 221 is selected by
15 the signal level on line DIRECT and is the opposite of
the bus selected by bus-in selector 380. Again, the
particular way the signals on bus SDO[7:0] are output
from SCSI expander 200A is not essential to this
invention.

20   A second input terminal of each OR gate in
plurality of OR gates 340_0 to 340_7 is connected to an
output terminal of a different AND gate in a plurality
of AND gates 330_0 to 330_7, e.g., a third plurality of
logic gates. As explained more completely below,
25 except when a message is being processed, the output
signals from plurality of AND gates 330_0 to 330_7 are
always inactive, e.g., low, so that plurality of OR
gates 340_0 to 340_7 pass the signals on bus SDI[7:0]
to bus 371.

30   A second input terminal of each AND gate in
plurality of AND gates 360_0 to 360_7 is connected to
an output terminal of a different NAND gate in a
plurality of NAND gates 350_0 to 350_7, e.g., a fourth
plurality of logic gates. As explained more completely
35 below, except when a message is being processed, the
output signals from plurality of NAND gates 350_0

to 350_7 are always active, e.g., high, so that plurality of AND gates 360_0 to 360_7 pass the signals on bus SDI[7:0] to bus 372.

Hence, independent of the state of
5   signal POLARITY on line 375, during non-message processing operation of expander 200A, circuit 250 passes the data without modification from input bus SDI[7:0] to output bus SDO[7:0]. Preferably, circuit 250 is designed such that the data timing of
10 pass-through signals is not corrupted, which can be done with conventional design and layout tools.

A message decode circuit 301 monitors information passing through expander 200A on line 302. As is known to those of skill in the art, monitoring the SCSI bus
15 phase and request and acknowledge signals on the SCSI bus are used to determine when a message is present. Moreover, in the message phase, the specific byte sequences are specified by the SCSI specification and also are known to those of skill in the art. Message
20 decode circuit 301 detects the first two bytes of a PPR message, and in response thereto drives an active signal on message-detected line 261 for the duration of the message. At other times, the signal level on line 261 from message decoder 301 is inactive, in this
25 embodiment. Message detected line 261 is connected to a first input terminal of each AND in plurality of AND gates 330_0 to 330_7 and to a first input terminal of each NAND gate in plurality of NAND gates 350_0 to 350_7.

30   After a message is detected by decoder 301, an active signal is driven on line BYTE_EN to a counter 310. Counter is 310 is clocked by a signal CLK on line 312 to counter 310 as each byte is transferred to expander 200A.

35   Various alternative embodiments can be used to clock counter 310. In a first embodiment, illustrated

in Fig. 4A, signal CLK is generated using the request
signal REQ or acknowledge signal ACK depending on the
direction of data transfer, as illustrated in Fig. 4C.
In this embodiment, line 261 is connected directly to
5   line 311.

In the embodiment of Fig. 4B, signal CLK is a free
running clock. In this embodiment, counter 310
receives the enable signal on line 261 and in addition
receives a count enable signal on line 311 from valid
10   message unit decoder 401. In addition, for the message
of interest in this embodiment, counter 310 is either
loaded with a value of two, or alternatively, the value
loaded in message-unit selection register 314 is the
number bytes after counter 310 starts to count, and not
15   the specific number of bytes in the message. In view
of these examples, those of skill in the art can
implement various configurations to provide the proper
signal level and timing on line 271.

Hence, counter 310 counts each byte in the PPR
20   message following detection of the message. The value
of counter 310 is a first input to a comparator 315. A
second input to comparator 315 is a value BYTENUM in a
message-unit selection register 314. Register 314
could be loaded by an on-chip processor, loaded from an
25   external source such as a SCSI initiator, or a host
system, or alternatively hard-coded. The way that a
particular value is loaded in message-unit selection
register 314 is not essential to this invention.

When the value from counter 310 equals value
30   BYTENUM, e.g., when a value of counter 310 has a
predefined relationship to the value stored in
register 314, comparator 315 generates an active signal
on message-unit detected line 271. This indicates that
the message-unit containing the sub-unit of interest is
35   on input bus SDI[7:0]. Alternatively, the signal on
line 271 could indicate that the next message-unit on

bus SDI[7:0] is the message-unit of interest. Again,
the particular way chosen to modify the message-unit
on-the-fly depends on the timing constraints introduced
by the circuit in combination with the timing
5   requirements for the buses connected to the expander.

Message-unit detected line 271 is connected to a
second input terminal of each AND gate in plurality of
AND gates 330_0 to 330_7 and to a second input terminal
of each NAND gate in plurality of NAND gates 350_0
10   to 350_7. Hence, circuit 250 detects a message and
then a particular message-unit within the message,
e.g., a pre-selected byte within the message, as
indicated by the output signals from decoder 301 and
comparator 315, respectively.

15   A value BITNUM in a sub-unit selection
register 321 is a first input to an encoder 320.
Encoder 320 drives an enable sub-unit output bus
EN_BIT[7:0]. Specifically, encoder 320 drives an
active signal on the line of enable sub-unit output bus
20   EN_BIT[7:0] corresponding to value BITNUM in
register 321 and the signals on the other lines of bus
EN_BIT[7:0] are held inactive.

Each line of enable sub-unit output bus
EN_BIT[7:0] is connected to a third input terminal of a
25   different AND gate in plurality of AND gates 330_0
to 330_7 and to a third input terminal of a different
NAND gate in plurality of NAND gates 350_0 to 350_7.
Hence, the AND gate corresponding to the value in
register 321 receives the active signal from
30   encoder 320, and generates an active signal on the
second input terminal of the OR gate to which it is
connected. This OR gate, in turn, generates an active
signal on the line of bus 371 corresponding to the
value in register 321. Similarly, the NAND gate
35   corresponding to the value in register 321 receives the
active signal from encoder 320, and generates an active

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signal on the second input terminal of the AND gate to
which it is connected. This AND gate, in turn,
generates an inactive signal on the line of bus 372
corresponding to the value in register 321. Hence, the
5   sub-unit of bus 371 that is defined by the value in
sub-unit selection register 321 is set to a first
selected value, and the sub-unit of bus 372 that is
defined by the value in sub-unit selection register 321
is set to a second selected value.

10   Various alternative embodiments of the SCSI
message manipulation circuit can be implemented in view
of this disclosure. For example, if circuit 250 is
being implemented in an device that uses only one type
of signal conditioning either logic gates 330_0
15   to 330_7 and 340_0 to 340_7, or logic gates 350_0
to 350_7 and 360_0 to 360_7 can be eliminated along
with multiplexer 370 and the polarity control signal.
This configuration still allows selecting any sub-unit
of any message unit in the message, but the state of
20   the selected sub-unit is fixed.

The logic can be simplified further if the sub-
unit of interest is always the same sub-unit in the
same message unit, e.g., bit seven of the last message
byte. In this case, the logic always forces bit seven
25   of the last message byte to a selected value as bit
seven leaves the expander. Therefore, the embodiments
described herein are illustrative only and are not
intended to the limit the invention to the specific
embodiments described.

30   For example, the message manipulation circuit can
be expanded to change multiple bits within a byte,
multiple bytes, or even multiple messages. In one
embodiment of message unit detector 270, comparator 315
represents a plurality of comparators, line 271
35   represents a plurality of lines with one output line
from each comparator in the plurality, and register 314

represents a plurality of registers. Similarly,
register 321 represents a plurality of registers. In
this embodiment, each line in the plurality of lines
271 also goes to encoder 320 to select the sub-unit

5   number in the corresponding one of the registers in the
plurality of registers 321. This configuration permits
modifying multiple message units on-the-fly, modifying
multiple sub-units in a message unit on-the-fly, or a
combination of the two.

10   If modifying multiple messages on-the-fly is of
interest, message decoder 301 represents a plurality of
message decoders with each message decoder providing an
enable signal to message unit detector 270. The enable
signal to message unit detector 270 is used to select

15   different message units from plurality of registers
314, or alternatively, to select a set of registers if
multiple units in the message are to be changed. In
view of Fig. 3, modifications can be made by those of
skill in the art to handle less complicated, or more

20   complicated message manipulation. However, in each
instance, the content of the message is detected on-
the-fly, and modified on-the-fly.